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TEXAS AGRICULTURAL EXPERIMENT STATION

A. B. CONNER, DIRECTOR
COLLEGE STATION, BRAZOS COUNTY, TEXAS

BULLETIN NO. 492 AUGUST, 1934

DIVISION OF RANGE ANIMAL HUSBANDRY

Cottonseed Meal in Rations of Horses and Mules

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**In cooperation with U. S. Department of Agriculture.
‡In cooperation with Texas Extension Service.
†As of August 1, 1934

More than 80 horses and mules varying in age from weanlings to 20 years old were fed one pound of cottonseed meal daily in connection with other feeds for 224 days to two years, and some of them received two pounds daily for a much longer period. There was not a single instance of any injurious effects from feeding the cottonseed meal to mares, weanlings, artillery horses, and work horses and mules. The animals receiving cottonseed meal in their rations made larger gains and shed their old hair earlier in the spring than similar groups not receiving cottonseed meal.

One Percheron mare receiving one pound of cottonseed meal daily for 938 days and a Standard-bred filly receiving two pounds daily from the time she became a weanling over a period of 686 days, represent the highest levels of cottonseed meal feeding in this investigation.

The results of the study reported in this Bulletin indicate that one or two pounds of 43% protein cottonseed meal will be a useful and valuable supplement to the rations commonly fed to horses and mules in the South.

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BULLETIN NO. 492 AUGUST, 1934

COTTONSEED MEAL IN RATIONS OF HORSES AND MULES

R. H. WILLIAMS*, J. M. JONES, AND J. H. JONES†

The correct feeding of horses and mules is an important problem in the South because of the large number of animals, the difference in kind and quality of feed available, and the climatic conditions. This study was made because it was believed possible to effect a practical improvement in the rations of horses and mules as a result of the inclusion of 1 to 2 pounds of cottonseed meal. The successful feeding of cottonseed meal to these animals is of particular interest and has commercial significance in this State and in the South because it is manufactured in large amounts and is easily obtainable; furthermore, it is a relatively cheap, highly concentrated protein feed which may well be included as a supplement to most farm-raised feeds, which are low in protein, fed to work stock in the South.

Although recognizing the value of cottonseed meal as a feed for bovine animals, a large number of stockmen have been reluctant to include this protein feed in horse and mule rations, being afraid that it might prove harmful.

Cottonseed meal has in instances in the South been fed to horses and mules for many years. In 1899 Connell and Kyle of the Texas Station (1) in a discussion of the feeding of cottonseed meal to horses wrote:

> "Some consider it a useful feed for horses and mules; others do not and report that it is hard to make them eat it."

At the Mississippi Station (2)it was reported in 1902 that mules refused to eat cottonseed meal. A similar conclusion based on the reaction of one team of mules to 2 pounds of cottonseed meal during a fourteen-day period was reached at the Kentucky Station (3). On the other hand, the Louisiana Planter (4) in 1902 reported that 1 to 2 pounds of cottonseed meal was fed to mules with success and that 6 pounds was considered the maximum quantity which can be fed per animal daily. Curtis of the North Carolina Station (5) in reporting the results of a three-year test in the feeding of cottonseed meal to draft animals stated:

> "There has been considerable diversity of opinion regarding the use of cottonseed meal for draft animals. On the whole, however, the weight of evidence seems to be in favor of this feed for work stock when it is fed with judgment . . . When fed in quantities ranging from ten to fifteen per cent of the total ration by weight, it will generally be eaten satisfactorily without any observable detrimental results.

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†The investigations reported in this Bulletin were made possible through the active cooperation of Professor D. W. Williams, Head, Department Animal Husbandry, A. and M. College of Texas, Fred Hale, Chief, Division Swine Husbandry, T.A.E.S., who represented the Feeding and Breeding Station, Dr. R. P. Marsteller, Professor of Veterinary Medicine and Surgery, A. and M. College of Texas, and Major J. E. Sloan, U. S. Army. Grateful acknowledgment is also due Ernest Gibbens, Texas County Agent, formerly of the Department of Animal Husbandry, who was instrumental in planning the investigation and who was active leader of the work during the first year.

At least at the conclusion of experiments extending over a period of three years, there was no evidence antagonistic to the continuous use of moderate quantities of this concentrate from the standpoint of health."

"It should never be undertaken to feed cottonseed meal alone. It is a very concentrated feed and for this reason, it should be used only as a supplement to carbonaceous and fat-producing feeds."

"The results obtained by the writer during three years of experimental work show that no ill effects will arise from the use of cottonseed meal if it is used with judgment, however, if it is unduly increased, it will not only be refused but will injure the condition and working efficiency of the animals."

"Only bright, fresh, light-colored cottonseed meal should be used. Meal which is of a dark yellow color is most likely to be old and somewhat musty. The stale condition of the meal is no doubt at times responsible for animals refusing to eat it."

'Cottonseed meal is an excellent laxative and for this reason, it is desirable to feed with corn, aside from the fact that it furnishes the deficiency of protein in corn."

"The effect of the meal on the coat of the animal is to make it smooth and glossy, having the same effect in this respect as linseed meal."

At the Iowa Station (6) six pounds of cottonseed meal was as effective as eight pounds of linseed oil meal in balancing 100 pounds of a grain

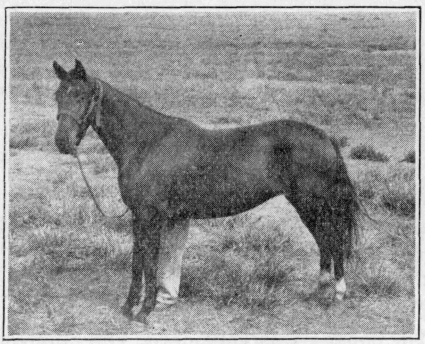

Fig. 1. Bess, a filly in Group 3, consumed 2 lbs. of cottonseed meal daily over a period of 686 days from the time she was a weanling weighing 483 lbs. She made a large gain, was first to shed the old coat of hair in the spring, and worked well.

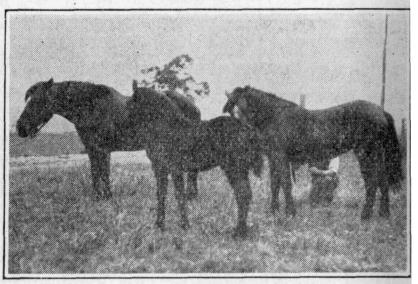

Fig. 2. Percheron mare, Flora, and her yearling and filly foals. Flora was fed 2 lbs. of cottonseed meal daily during a period of 538 days, during which time both foals were raised. The yearling filly received a ration containing 2 lbs. of cottonseed meal daily over a period of 202 days prior to the taking of this picture.

mixture containing 15 pounds of ground oats, the balance consisting of ground corn. The horse receiving cottonseed meal consumed 1.07 pounds per head daily. The summary statements are quoted as follows:

"The health, spirit and endurance of work horses were the same when fed corn with a moderate amount of oil meal, or gluten feed, or cottonseed meal, as when fed a corn and oats ration supplying a similar nutritive ratio."

"Cottonseed meal gave somewhat better results on the whole than oil meal. The ration containing it was fully as palatable and as efficient in maintaining the health and weight of the horses; it was less laxative, and a little cheaper . . . At the usual prices of the feeds,

their use resulted in a substantial lowering of the cost of maintaining the horses."

Bell and Williams (7) of the Bureau of Animal Industry in a report covering the feeding of cottonseed meal to horses, stated that

> "one pound a day per 100 pounds live weight is the most satisfactory quantity to feed. Although some animals will consume more with satisfactory results, it is not advisable to exceed this limit . . . Mares which were fed cottonseed meal during pregnancy did not show any ill effects noticeable on the colts when foaled. From observations in this experiment, cottonseed meal does not seem to prevent mares from becoming pregnant."
>
> "No apparently beneficial effects were observed on the coats of the horses receiving cottonseed meal. In some teams, those receiving cottonseed meal had the better looking coats, while in other teams the horses not receiving the meal had the smoother and glossier coats."
>
> "The mares in this experiment thrived better and consumed their ration of cottonseed meal more satisfactorily after they were turned out to grass . . . "

The same authors (Bell and Williams) report in U. S. Department of Agriculture Farmers' Bulletin 1030 that

> "cottonseed meal may be fed to horses in limited quantities if due care is exercised in obtaining bright choice meal and the animals are put on the diet gradually . . . Favorable results have been obtained in some parts of the South in the feeding of cottonseed meal in connection with black strap molasses and grain . . . While cottonseed meal has been fed in large quantities in isolated cases, the best results may be obtained in isolated cases by limiting the amount to 1 pound per day per 1000 pounds live weight and giving special attention to the horses being fed."

At the Mississippi Station, Templeton (8) fed cottonseed meal in the rations of 20 mules with the following results:

> "Ten mules fed a ration composed of 10.28 pounds of ear corn, one pound of cottonseed meal (of 39.56 per cent protein content), three pounds of oats, and 15 pounds of Johnson grass hay per thousand pounds of live weight per day consumed their feed with apparent relish."
>
> "Ten mules fed a ration of 11.4 pounds of ear corn, 1.1 pounds of cottonseed meal and 10 pounds of Johnson grass hay per thousand pounds live weight per day, showed a marked difference in desire to consume the meal. Four of the mules took to the ration readily and would have consumed more meal. Six of the ten refused to consume more than 1.1 pounds of meal per thousand pounds of live weight daily."

In the Mississippi test the purpose was to study methods of feeding cottonseed meal; therefore no attempt was made to feed the same amount of total digestible nutrients in comparable lots.

> "There was no noticeable difference between the mules of the four lots as to the way they stood their work and the heat. All four rations proved satisfactory in these respects."
>
> "There was no difference in the condition of the coats of hair of the mules in the lots consuming cottonseed meal as compared with the

mules that did not receive the meal. There was apparently more difference in the glossiness of the coat of hair of the individual mule, the difference depending on the condition and vitality, than there was between lots."

No differences were observed in health, spirit, and endurance, between the groups receiving the rations, either with or without cottonseed meal.

EXPERIMENTS WITH MIXED CLASSES

The animals used were a mixed lot of horses and mules of various ages, weights and service belonging to the College Animal Husbandry Department. There were 11 registered Percherons, 5 standard-breds, 2 saddle-breds, 1 thoroughbred, 5 grades and crossbreds, 4 mules, and 1 horse-mule hybrid. Only 8 out of 34 animals were in the test the entire 938 days. A number of head were removed from the test on account of sale or other causes before a full year was completed. The records from such animals were included when there were comparable individuals in other groups.

The initial and final weights were the averages of the animals' weights taken for three consecutive days. Individual weights were usually taken at 28-day intervals to note changes in condition.

The animals were divided into three similar groups, each of them being fed a designated concentrate mixture for at least one of the three periods of the feeding trial, as shown in Table 1.

Table 1. Concentrates fed besides mixed roughages

Group	Method of feeding
1	No cottonseed meal. Basal ration*.
2	1 lb. cottonseed meal substituted for 1 lb. basal ration, fed Group 1.
3	2 lbs. cottonseed meal substituted for 2 lbs. basal ration, fed Group 1.

*Basal ration: Ground threshed milo 80 lbs., rice bran 20 lbs., air-slacked lime 1 lb., and salt 1 lb. During the second and third years, ground threshed kafir replaced the milo and 2 pounds of steamed bone meal was used instead of 1 lb. of air-slacked lime.

The amount of concentrates fed depended upon the size, age, condition, and general requirements of each animal. Comparable animals in the various groups were limited to about the same amounts of concentrates. Some variation was necessary due to the amount of work done or to other conditions. Work-mares raising foals received more concentrates than similar mares not in foal or not working.

The work animals were given their concentrates in equal amounts, morning, noon, and night. Brood mares and young or idle animals were fed only twice a day. All grain or other concentrate feed was weighed and fed separately to each animal. The hay, however, was not weighed to any of the animals; so it is not possible to report complete rations for individuals.

The check group and comparative groups receiving 1 or 2 pounds of cottonseed meal were given similar treatment insofar as possible. They were not kept in separate groups. The work stock were turned out to pasture overnight or kept in dry lot and fed hay. The idle animals and young stock had pasture during fair weather, and all stock were sheltered when the weather was very cold or wet.

Burr clover and oat pasturage furnished considerable feed during the winter and Sudan and improved grass pasturage were available most of the summer months. There were periods of varied duration when prairie, Sudan, and alfalfa hays were used.

Most of the threshed milo used the first year and the threshed kafir used the second and third year were No. 3 grade. These feeds were ground to a coarse meal. The grinding was done about twice a week to keep the

Fig. 3. Control animals Group 1. Picture taken at end of third year's test. The four mares each raised a foal. Three of the mares did considerable work during the winter and spring months. The five mature animals lost an average of 24 pounds per head during the 252 days that they received the control ration, which did not contain cottonseed meal.

feed as fresh as possible. The rice bran was obtained in small amounts during the summer months to avoid rancidity. The cottonseed meal contained 43% protein. Ordinary granulated salt, air-slacked lime, and steamed bone meal were the mineral supplements.

Results First Year

As shown in Table 2, all five of the mature animals in Group 1, not receiving cottonseed meal, lost weight during this period, while only one in each of the groups fed cottonseed meal lost weight. The Percheron mare, Jewella, in Group 2, lost 120 pounds, but she raised a foal and did some work. Likewise, Flora, Group 3, lost in weight, but she raised a foal and suffered from fistula. The mule fed 2 pounds of cottonseed meal gained 40 pounds as compared to the one not fed cottonseed meal, which lost 20 pounds. The young animals in each group made good gains but those receiving cottonseed meal gained the most. The observed weights of the animals during the first year strongly indicate that one or two pounds of

Table 2. Summary of First Year's Feeding Test (College Animal Husbandry Department Stock) Nov. 10, 1927 to Oct. 11, 1928; 336 days

Animal	Age, years 1927	Initial weight lbs.	Final weight lbs.	Gain or loss lbs.	Concentrates fed daily			Remarks
					Grain lbs.	Cotton-seed meal lbs.	Total con-centrates lbs.	
Shorty (mule mare)	16	1340	1320	—20	15.7	0	15.7	Worked. Chronic colic.
Linette (Percheron mare)	3	1436	1340	—96	15.1	0	15.1	Raised foal. Idle.
Lily Duke (Percheron mare)	6	1500	1420	—80	16.1	0	16.1	Foal died. Worked. Sold after 214 days.
Humbert (Percheron mare)	4	1730	1670	—60	17.7	0	17.7	Aborted. Worked.
Blondie (Morgan mare)	13	1160	965	—195	16	0	16	Raised foal. Idle.
Todd (Standard bred mare)	½	533	850	317	6.4	0	6.4	Weanling.
Jeweler (Percheron stallion)	½	756	810	54	7.5	0	7.5	Sold after 112 days.
Nellie (Percheron mare)	18	1415	1430	15	15.9	1	16.9	Worked.
Jewella (Percheron mare)	8	1440	1320	—120	14.5	1	15.5	Raised foal. Worked.
Eloise (Percheron mare)	3	1490	1590	100	15	1	16	Worked.
Blondora (Morgan mare)	½	665	860	195	8.3	1	9.3	Weanling.
Flowerdale(3) (Standard bred mare)	3	860	1060	200	10	1	11	Idle. Sold after 280 days.
Jazman (Percheron stallion)	½	730	880	150	6	1	7	Sold after 112 days.
Bingham (mule mare)	16	1340	1380	40	14.6	2	16.6	Worked.
Pearlette (Percheron mare)	9	1480	1490	10	14.6	2	16.6	Worked.
Flora (Percheron mare)	11	1445	1350	—95	12.3	2	14.3	Raised foal. Fistula.
Flowerdale(2) (Standard bred mare)	4	960	980	20	11.2	2	13.2	Raised foal. , Idle.
Bess (Standard x Saddle mare)	½	483	845	362	5.6	2	7.6	Weanling.
Juror (Thoroughbred stallion)	1	640	820	180	5.6	2	7.6	Yearling.
Flowerdale (Standard bred mare)	11	1080	1250	170	11.2	2	13.2	Idle.

cottonseed meal in the ration fed daily to work horses, mules, brood mares, and young colts will increase gains. A record of performance of individual animals is given in Table 2.

Results Second Year

A number of animals, as shown in Table 3, were changed between the three groups for the second year of feeding. The Percheron mare, Nellie, was continued on the ration that included one pound of cottonseed meal. Three head were continued on the ration carrying 2 pounds of cottonseed meal. This was done to permit a comparison between similar animals fed cottonseed meal through one- and two-year periods.

The gains were again larger and more consistent for the animals fed cottonseed meal than for those not fed the meal. Two of the mares in each of the groups raised foals that were strong and vigorous. There

Fig. 4. Group 2 animals fed one pound of cottonseed meal per head daily. Picture taken at end of the third year. These animals gained an average of 23 lbs. per head during the 252 days. Three of the mature animals each received one pound of cottonseed meal daily for 604 days, while the Percheron mare, Nellie, consumed one pound of cottonseed meal daily over a period of 938 days.

was no indication of any ill effects in either of the cottonseed meal groups. The yearling filly, Bess, which had received 2 pounds of cottonseed meal daily for 2 years, made a rapid growth and was always thrifty. The mare, Flora, also fed 2 pounds of cottonseed meal daily for 538 days showed no apparent ill effects.

Results Third Year

Each of the three groups included one mule and one Percheron mare that had been given the same kind of feed the previous year. This was

Table 3. Summary of Second Year's Feeding Test (College Animal Husbandry Department Stock) Oct. 11, 1928 to Sept. 26, 1929; 350 days

Animal	Age, years 1928	Initial weight lbs.	Final weight lbs.	Gain or loss lbs.	Concentrates fed daily			Remarks
					Grain lbs.	Cotton-seed meal lbs.	Total concentrates lbs.	
Bingham (mule mare)	17	1380	1366	—14	14	0	14	Worked.
Pearlette (Percheron mare)	10	1490	1460	—30	15	0	15	Worked.
Jewella (Percheron mare)	9	1320	1417	97	15	0	15	Aborted. Worked.
Rofanny (Morgan mare)	7	1245	1183	—62	12	0	12	Raised foal. Worked.
Flowerdale(2) (Standard bred mare)	5	980	1017	37	10	0	10	Raised foal. Idle.
Todd (Standard bred mare)	1	850	1010	160	9	0	9	Unbroken.
Mack (Standard x Saddle stallion)	½	560	750	190	7	0	7	Sold after 199 days.
Becky (mule mare)	½	550	1047	497	8	1	9	Weanling.
Nellie (Percheron mare)	19	1430	1370	—60	13	1	14	Foal died. Worked.
June (grade Percheron mare)	22	1410	1452	42	14	1	15	Worked.
Blondie (Morgan mare)	14	965	1098	133	10	1	11	Raised foal. Idle.
Fay Wilcox (Saddle mare)	9	1080	1123	43	8	1	9	Raised foal. Idle.
Rofanny Filly (Morgan mare)	2	665	800	135	8	1	9	Sold after 199 days. Idle.
Lena (Crossbred mare)	½	440	770	330	6	1	7	Sold after 199 days. Idle.
Shorty (mule mare)	17	1320	1313	—7	12	2	14	Worked.
Linette (Percheron mare)	4	1340	1340	0	14	2	16	Raised foal. Worked
Flora (Percheron mare)	12	1350	1240	—110	10	2	12	Raised foal. Sold after 202 days. Fistula.
Madeline (Percheron mare)	½	620	920	300	6	2	8	Sold after 202 days.
Black Annie (Standard bred mare)	4	1020	1090	70	8	2	10	Idle.
Bess (Standard x Saddle mare)	1	845	1002	157	7	2	9	Worked.
Flowerdale (Standard bred mare)	12	1250	1120	—130	8	2	10	Sold after 192 days. Worked. Sweeny.
Dan (Standard x Saddle stallion)	½	440	680	240	5	2	7	Sold after 199 days.

done to further note the effects of feeding 1 or 2 pounds of cottonseed meal for a long period.

Although three mares in Group 1 not receiving cottonseed meal lost weight, no significance is attached to this result because these mares were raising young foals and did some work. As shown in Table 4, the gains were larger and more consistent in Group 3, fed 2 pounds of cottonseed meal, than for Group 2, fed one pound of meal, and both exceeded Group 1. The four animals that received cottonseed meal continuously during the second and third years gained in weight and looked better

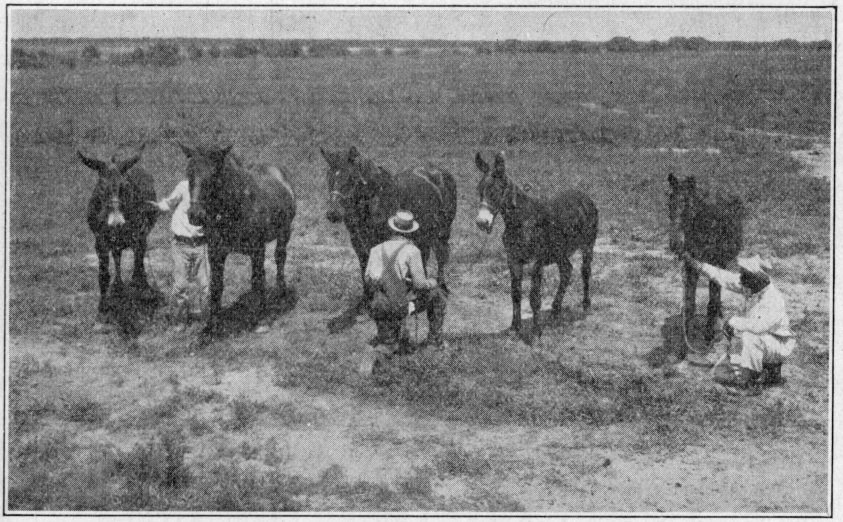

Fig. 5. Group 3 animals fed two pounds of cottonseed meal. Picture taken at end of the third year. Each of the mature animals in this group received two pounds of cottonseed meal two out of three years of the investigation. The mule and one Percheron mare, Linette, were fed two pounds of cottonseed meal per head daily during a 602-day period. The two yearlings were fed two pounds of cottonseed meal from the time they were weaned. As individuals, or as a group, they gained more than comparable animals in the other groups.

than when the test began. A young mule receiving 1 pound of cottonseed meal daily from the time she was weaned weighed 1172 pounds when 24 months old and had done considerable work since 20 months old. There was no evidence of ill effects on any of the animals as a result of the cottonseed meal feeding.

Results for Three Years

The nature of the data does not permit the expression of gains in terms of averages for the three groups; however, the individual records of animals within the three groups show that the gains were larger and more consistent for the ones receiving cottonseed meal. As between the groups fed one and two pounds of cottonseed meal per head daily, the

Table 4. Summary of Third Year's Feeding Test (College Animal Husbandry Department Stock) Sept. 26, 1929 to June 5, 1930; 252 days

Animal	Age, years 1929	Initial weight lbs.	Final weight lbs.	Gain or loss lbs.	Concentrates fed daily			Remarks
					Grain lbs.	Cotton-seed meal lbs.	Total con-centrates lbs.	
Bingham (mule mare)	18	1366	1392	26	14	0	14	Worked.
Jewella (Percheron mare)	10	1417	1383	—34	16	0	16	Raised foal. Worked.
Flowerdale(2) (Standard bred mare)	6	1017	1057	40	12	0	12	Raised foal. Worked.
Rofanny (Morgan mare)	8	1183	1070	—113	12	0	12	Raised foal. Worked.
Marvel Lady (Saddle mare)	4	1055	1017	—38	9	0	9	Raised foal. Idle.
Becky (mule mare)	1	1047	1172	125	11	1	12	Worked.
Nellie (Percheron mare)	20	1370	1388	18	14	1	15	Worked.
Blondie (Morgan mare)	15	1098	1047	—51	11	1	12	Raised foal. Idle.
Fay Wilcox (Saddle mare)	10	1123	1123	0	11	1	12	Raised foal. Idle.
Shorty (mule mare)	18	1313	1340	27	12	2	14	Worked.
Pearlette (Percheron mare)	11	1460	1520	60	17	2	19	Worked.
Linette (Percheron mare)	5	1340	1343	3	15	2	17	Worked.
Lily* (mule mare)	½	550	685	135	3	2	5	In test 112 days.
Octet** (1/8 jack, 7/8 horse, mare)	½	510	732	222	3	2	5	In test 169 days.

*Placed in test Feb. 13, 1930
**Placed in test Dec. 19,1929

differences are too small and irregular to permit conclusions as to whether one or two pounds of cottonseed meal per head daily is the better for horses or mules.

The young animlas made larger and more uniform gains than the mature animals. All the young animals made good gains but the larger

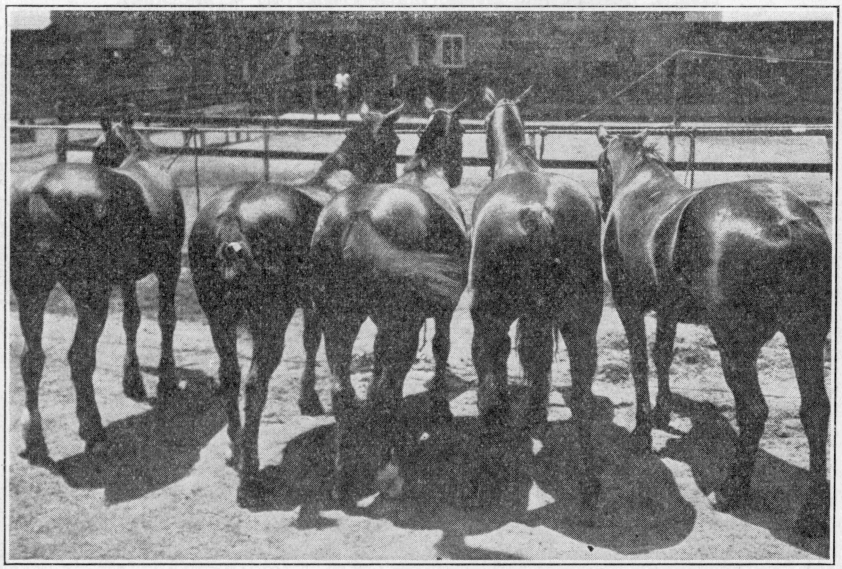

Fig. 6. Some of the Heavy Artillery horses, Group 1, at the end of the second year's experiment. Each of he 24 horses in this group during the second year's experiment received one pound of cottonseed meal for a period of 244 days, during which time they gained more than any other group.

gains were made by those receiving cottonseed meal. The weight records show that 4 out of 15 mature animals in Group 1, 8 out of 15 in Group 2, and 7 out of 11 in Group 3 gained in weight.

The basal feed mixture fed to Group 1 was considered satisfactory but it is evident that the addition of either 1 or 2 pounds of cottonseed meal to the ration made an improvement.

Apparently 1 or 2 pounds of cottonseed meal per head daily was a safe allowance, since one mare having received 1 pound of cottonseed meal daily for 938 days showed no ill effects and 4 animals fed 2 pounds per head daily during the second and third years of the feeding trial were likewise thrifty.

EXPERIMENTS WITH WORK STOCK

This test was an observation of the effect of ten per cent of 43% protein cottonseed meal in a ration of ground threshed milo, oats, and

sorghum hay on the health, weight, ability to work, resistance to heat, and the vigor and spirit of work animals.

Two teams of mules and one of horses worked on the Feeding and Breeding Station farm were used in this test. They were paired into two groups shown in Table 5. The animals in each team were given almost

Table 5. Division into groups. Initial weights Oct. 6, 1927 (lbs)

Team	Kind	Group 1 No cottonseed meal			Group 2 10% cottonseed meal		
		Name	Age	Weight	Name	Age	Weight
I	horses	Doc	9	1322	Dan	9	1270
II	mules	Blue	7	1061	Ma	6	982
III	mules	Rodie	6	1123	Emma	6	1080
Average of 3 head			7.3	1169		7	1111

identical work, care, and amount of concentrate feeds. They were in good condition when the test began and were accustomed to working in teams of twos as indicated. They were considered well matched although the teammate fed cottonseed meal was the lighter in each of the teams. Two teams remained in the test the entire two years. The other team, Rodie and Emma, not owned by the Experiment Station, remained in the test 17 months.

The control group was fed concentrate feed mixture No. 1, as shown in Table 6. Concentrate mixture No. 2 fed the compared animals was the same as feed mixture No. 1, except that 30 pounds of ground threshed milo was replaced by 30 pounds of 43% protein cottonseed meal.

Table 6. Concentrate mixtures

Feed	No. 1		No. 2	
	Pounds	Per cent	Pounds	Per cent
Ground threshed milo	200	67	170	57
Whole oats	100	33	100	33
43% protein cottonseed meal			30	10

The oats and threshed milo fed were of No. 2 grade. Only one week's supply of milo was ground at a time. The sorghum hay fed as the roughage was bright in color and well cured.

The animals were weighed on three consecutive days at the beginning and end of the experiment and every 28 days during the experimental period.

The concentrate feed mixture was weighed to each animal three times daily in equal amounts and fed in separate box stalls. But when the

animals were not working the noon feed of concentrates was omitted and on Saturday nights they were turned to a Bermuda grass pasture where they remained until Monday morning. The allowance of concentrates varied from .7 to 1.4 pounds daily per 100 pounds live weight according to individuality, condition, and amount of work being done. After finishing their grain feed in the evening, they were turned into a dry lot with sorghum hay, water, and salt available.

Table 7. Summary of results at Feeding and Breeding station. Oct. 6, 1927 to Oct. 6, 1929

Name	Average daily concentrates (pounds)	Average weights		Gain pounds	Days worked	
		Initial pounds	Final pounds		First year	Second year
Group 1. Given no cottonseed meal:						
Doc	12.42	1322	1336	14	186	222
Blue	10.00	1061	1126	65	171	227
Rodie	11.92	1123	1192	69	211	66*
Average	11.45	1169	1218	49	189	172
Group 2. Given 10% cottonseed meal:						
Dan	12.20	1270	1374	104	186	222
Ma	10.00	982	1018	36	176	225
Emma	11.94	1080	1104	24	211	66*
Average	11.38	1111	1165	54	191	171

*Data for 17 months with this team instead of 24 months as with the other animals.

Results

A summary of the results is given in Table 7.

The average amount of concentrates fed was about one pound per 100 pounds live weight in each of the groups. On this basis the group fed concentrate mixture No. 2 received an average of 1.1 pounds of cottonseed meal per head daily.

Each of the animals in the two groups gained in weight during the two years feeding period but the difference in gain between the groups was very small and there was little difference in the general physical condition of the two groups. However, the animal that made the largest gain was fed cottonseed meal and his team-mate, not fed meal, made the smallest gain.

The gelding, Dan, was known to be subject to colic but during the two years he remained on the cottonseed meal ration he had only one mild attack. No other sickness or digestive troubles were observed among the rest of the animals during the course of the experiment.

The teamsters could not distinguish any difference between the two groups in their ability to work during hot weather. Although there was little difference in the condition of the animals in the two groups during

the test, the teamsters stated that the ones fed cottonseed meal worked better and were more active than they were on previous feed mixtures which contained no cottonseed meal.

EXPERIMENTS WITH ARTILLERY HORSES

The object of this test was to determine the effect of replacing one pound of No. 2 oats with one pound of 43% protein cottonseed meal when horses were fed the standard army ration of oats and prairie hay.

General Conditions

Fifty-eight artillery horses belonging to the U. S. Army Military Training Unit at College Station, Texas, were selected from a larger group, weighed and divided into four groups for the cottonseed-meal feeding tests, as shown in Table 8.

Table 8. Arrangement of the groups. Pounds of concentrates fed daily with prairie hay

Horses			First year		Second year	
Group	No.	Kind	Oats	cottonseed meal	Oats	Cottonseed meal
1	24	Heavy	11	0	10	1
2	23	Heavy	10	1	11	0
3	5	Light	10	0	9	1
4	6	Light	9	1	10	0

The main difference between the heavy and light groups was one of weight, yet conformation was a factor in the division. The heavy group was used entirely for draft while the light group was used for riding and for student classes in equitation.

The horses in Groups 1 and 2 were somewhat similar in age, weight, and condition; however, Group 1 had fewer horses known as poor feeders. This disproportion in the number of hard feeders was made because of the desire to learn what effect the cottonseed meal would have on them. These horses had been known for about four years to be bony, rough animals that would not get fat. The second year the rations fed Groups 1 and 2 were reversed.

The light horses, Groups 3 and 4, received one pound less oats per head daily than the heavy horses. Their rations were also reversed for the second year's test.

All the horses used in these tests had been in the artillery service at least one year. All the horses in Groups 1, 2, and 3 except one were 14 to 20 years old. Those in Group 4 and the one head from the other group were 6 to 9 years old, and were in their second year of service. Their teeth were examined each year by the college veterinarians, and were kept in as good condition as possible. Except for the two mares the animals

were all geldings. Each horse was identified by a number burned into the left hoof or by a brand on the neck. These horses were more standardized than most groups of animals. They were gentle, well broken, and were accustomed to the conditions under which they were maintained.

Summer Management

The horses were kept in a 600-acre pasture from about June 10 to August 20 of each year. They were fed 2 to 4 pounds of oats per head daily spread out on prairie hay while on pasture. This feed on pasture kept them in fair condition and made daily inspection of all animals comparatively easy.

Feeds Used

Baled Texas and Oklahoma prairie hay purchased as No. 2 grade was the sole roughage fed. The oats fed were Texas oats of No. 2 grade.

Table 9. Chemical composition of feeds used* (per cent)

Feed	Water	Ash	Protein	Fat	Crude fiber	Nitrogen free extract
Prairie hay	9.23	8.20	4.19	2.42	28.44	47.52
Whole oats	10.13	3.89	11.12	4.53	11.84	58.49
Cottonseed meal	8.57	5.81	43.37	6.87	9.14	26.24

*Analyses reported by Dr. G. S. Fraps, Chief, Division of Chemistry, T. A. E. S.

Stable Management

These horses were given much better care than most farm horses receive. They were groomed every morning except Sunday, and strict routine was followed in feeding, watering, and management. Hay was fed indoors in bad weather and in large racks in an open yard at 11 a.m. and 4 p.m. in fair weather. The average allowance of hay was about 12.3 pounds per head daily. The grain ration was measured to each animal three times daily at 6 and 11 a.m. and 4 p.m. The allowance of cottonseed meal was spread over each feed of oats the first year but the second year the meal was fed only at the noon and evening feedings. A small amount of wheat bran was fed. The first year the bran was mixed with the oats; but the second year, on each Saturday evening, it was fed in place of oats. In this way the horses received wheat bran at an average rate of about one-fourth pound daily.

When the weather was fair the horses were turned loose into the corral at 9 a.m. and at 1 and 5 p.m. for exercise, water, and salt. If the weather was bad they were kept tied in the stables and led to water or turned out for a short time just before feeding the grain ration.

The corral was 90 feet wide by 300 feet long. It was covered with cinders and well drained. The manure and litter were removed each

morning. Upwards of 75 horses used this corral but this area furnished considerable exercise. The older horses abused some of the younger ones and certain timid ones were constantly on the move. The black horses seemed to have a tougher hide than the bays, as the latter were more sensitive to bites.

Work Done

Twice a week all horses were out for drill for two hours' hard work. This was the only work done by the horses weighing over 1200 pounds except for a few head that did some hauling. The light artillery horses

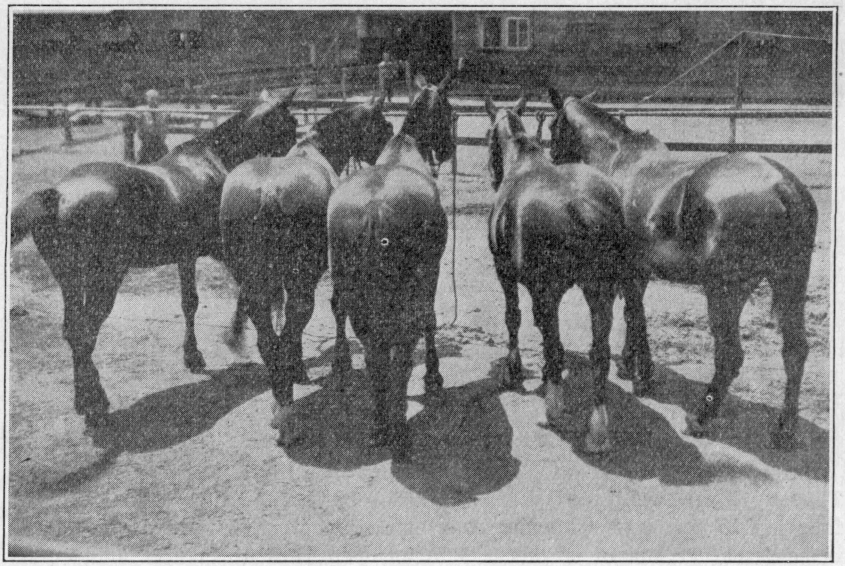

Fig. 7. Some of the Heavy Artillery horses, Group 2, at the end of the second year's experiment. These horses received the Standard Army ration. They lost an average of 11 pounds as compared with an average gain of 9 pounds per head in Group 1, second test.

and others weighing less than 1200 pounds were used in equitation classes or were ridden occasionally by students. The horses were not worked hard but had more work to do the second year of the test than the first.

Weighing

All the horses were weighed individually when the tests began and ended each year, and usually at 28-day intervals during the period of the tests. Period weights were not taken on animals in the hospital pen on weighing dates. The horses were remarkably uniform in their weights and it is believed that the uniformity in their feeding and management makes single weighings fairly reliable.

Results First Year

Because the horses were getting too fat the oats were reduced one pound per head daily in the four groups 152 days after the test began. Table 10 shows the weights and gains of the four groups during the 224 days of the first year's test.

Table 10. Average weights and gains of artillery horses, Oct. 11, 1928 to May 23, 1929—224 days

Group	Number	Kind	Initial weight, lbs. Oct. 11, 1928	Final weight, lbs. May 23, 1929	Gain lbs.
1. No cottonseed meal	24	Heavy	1156	1213	57
2. Cottonseed meal	23	Heavy	1125	1204	79
3. No cottonseed meal	5	Light	1041	1087	46
4. Cottonseed meal	6	Light	915	916	1

Heavy Artillery Horses: Group 1, controls, not fed cottonseed meal, ranged in weight from 1004 to 1312 pounds per head when the test began. They made an average gain of 57 pounds during the test and only one horse lost weight and he was the lightest horse in the group both at the beginning and end of the experiment.

The horses in Group 2, fed cottonseed meal, were 31 pounds per head lighter in the beginning than the Group 1 horses. They made considerably larger gains than the Group 1 horses, averaging 79 pounds per head, or 38.6 per cent, greater gain per head than Group 1. Only one horse in this group lost weight but he was a poor feeder and did extra work. This group gained the most of its advantage over Group 1 in the first 56 days of the test.

The average difference in gain of 22 pounds per head with a probable error of the difference of ± 9.5 pounds, is not great enough to justify the conclusion that cottonseed meal was responsible for increasing the gains in Group 2 over those made by the horses in Group 1, given the ordinary army ration.

Light Artillery Horses: The two groups of artillery horses were not quite comparable, as Group 3 contained four old horses that had become immune to strangles and Group 4 was composed of six young horses that had two set-backs during this period due to strangles. The four old horses in Group 3 gained 20 to 92 pounds per head, which corresponds well enough with the heavy horses in Group 1.

The rations for all groups seemed to be adequate and liberal enough, for at the end of the test only two animals had lost weight and nearly all were in especially good condition.

Gains and Losses in Weight During Summer: The first week in June 1929, the horses were turned out to pasture consisting of native grasses,

weeds, and brush. They were given good care during the summer and were fed limited amounts of oats and prairie hay. On August 20, 1929 the pasturage had become limited and they were returned to the military stables and lots, but they were not weighed until October 14, the beginning of the second year's test. Table 11 is a record of their weights during the summer or resting period.

Table 11. Average weights during year (pounds)

	Group 1	Group 2	Group 3	Group 4
Number of head	24	23	5	6
Daily feed cottonseed meal during winter	0	1	0	1
Initial weight October 11, 1928	1156	1125	1041	915
Beginning of rest period, May 23, 1929	1213	1204	1087	916
End of rest period, October 14, 1929	1181	1153	1060	971
Gain or loss during rest period	—32	—51	—27	55
Gain for the year	25	28	19	56

The horses in Group 4 made a gain of 55 pounds per head during the rest period, which was probably due to their recovery from the strangles.

The greater loss in weight of the horses in Group 2 on pasture may have

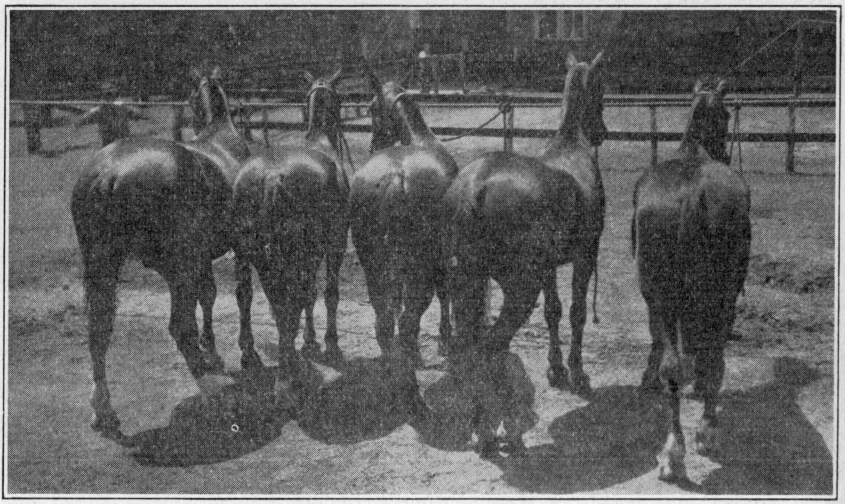

Fig. 8. The light Artillery horses in Group 3 a tthe end of the second year's experiment. This group received one pound of cottonseed meal per head daily during a 224-day feeding period and the loss in weight averaged 14 lbs. per head.

been due to the fact that these animals were fatter than any other group when turned to pasture. The summer losses seemed to be in direct proportion to the condition of the horses when turned to pasture. It will be noted that all groups made an appreciable gain for the entire year.

The horses in Group 2 lost more than any of the other groups during the summer, but they had gained much during the feeding trial. Group 4 gained well during the summer. The result was that both groups at the end of the year were relatively heavier than either of the groups not given cottonseed meal.

Results Second Year

The second year's test was a continuation of the first year's work, except the rations were reversed between the comparable groups. Cottonseed meal was fed as in the first year except that it was included only at the noon and evening feedings. All horses were tied in place before any grain was fed and a longer time was given the horses to eat the noon feed of concentrates than in the previous year. The final weighing day was quite hot and it is believed that weights taken then were lower than would have been obtained by the average of three consecutive days' weights.

Table 12. Average weights and gains of artillery horses, Oct. 14, 1929 to May 26, 1930—224 days

Group	Number	Kind	Initial weight, lbs. Oct. 14, 1929	Final weight, lbs. May 26,1930	Gain or loss
1. Cottonseed meal	24	Heavy	1181	1190	9
2. No cottonseed meal	23	Heavy	1153	1142	—11
3. Cottonseed meal	5	Light	1060	1046	—14
4. No cottonseed meal	6	Light	971	912	—59

Heavy Artillery Horses: As shown in Table 12, the heavy artillery horses in Group 1, fed cottonseed meal the second year, averaged 1181 pounds at the beginning and ranged in weight from 940 to 1360 pounds. They made an average gain of 9 pounds per head during the 224-day test. Fourteen head gained 10 to 75 pounds each, three remained the same weight, and seven lost 10 to 60 pounds each. The greatest gains were made during the first 56 days of the test, but the weights were well maintained throughout the period. During the two years the horses in this group gained an average of 34 pounds per head. They were a heavier and more vigorous lot of horses than Group 2, which received cottonseed meal the first year.

The Group 2 horses, fed the control ration of oats and hay the second year, averaged 1153 pounds at the beginning of this test and ranged in weight from 1000 to 1280 pounds. They made small gains during the first 56 days, after which they remained near the initial weights until the last weighing, at which time they averaged a loss of 11 pounds per head for the period of 224 days. Fourteen head lost 5 to 45 pounds per head, three maintained their weights, and six gained 5 to 30 pounds per head. The group finished the two years' test with an average gain of 17 pounds per head as compared with 34 pounds for Group 1.

When the gains and losses in weight in the two groups of heavy artillery horses are compared, a significant increase in gain is noted in favor of feeding one pound of 43 per cent protein cottonseed meal in place of one pound of oats in the standard army ration of oats and hay. Group 2, not fed cottonseed meal, lost 11.5±3.0 pounds in comparison with an average gain of 9.4±4.6 pounds per head in Group 1, fed one pound of cottonseed meal daily. The difference in the two groups was 20.9±5.5 pounds, which is significant.

A comparison of the gains of the same group as shown in Table 13 during the two different years with rations reversed shows a significant difference in each instance. The difference in gains between the two years for Group 1 was 47.0±6.9 and for Group 2 was 90.2±8.5 pounds, which was also significant. The horses in Group 2 weighed uniformly heavier during the first test on the ration that included cottonseed meal than the second year when fed the oats and prairie hay ration. But the opposite condition obtained in Group 1, which gained uniformly more the first year when they were not getting meal than the second year when receiving cottonseed meal. However, none of the groups did as well the second year as the first, since they were heavier when started on feed and were worked harder the second year.

Table 13. Summary of weights for each 224-day period (pounds)

Year	Number	Cottonseed meal	Average weights		Average gain or loss
			Initial	Final	
First					
Group 1	24	0	1156	1213	57
Group 2	23	1	1125	1204	79
Second					
Group 1	24	1	1181	1190	9
Group 2	23	0	1153	1142	—11
Average of both years	47	No meal	1155	1178	23
Average of both years	47	1 lb. meal	1153	1197	44

In each test the heavy horses receiving cottonseed meal gained more than the control group given the army ration. The average gain of the 47 horses fed for 224 days was 44 pounds when fed meal, while the same animals gained only 23 pounds when fed the army ration of oats and prairie hay. It seems reasonable to believe that the cottonseed meal was responsible for this difference of 21 pounds in gain.

Light Artillery Horses: The light horses in Group 3 receiving cottonseed meal averaged 1060 pounds at the beginning of the second test, and this was the greatest average weight reached by the group during the year. This group held their weight much better than Group 4, not fed cottonseed meal. Although they showed an average loss of 14 pounds per head, if one young horse with a loss of 85 pounds were eliminated as unsatisfactory,

the remaining four older horses would have shown an average gain of 4 pounds per head. This would rank them next to Group 1, and ahead of Group 2.

The average weight of the young horses in Group 4 was 971 pounds when the test began. They showed an average loss of 59 pounds per head for the feeding period. They lost 10 to 120 pounds per head and showed a tendency to decrease in weight throughout the period.

Observations

At the close of the two years' trials Major John E. Sloan in charge of the artillery unit, who followed the progress of both tests very closely, made this statement: "Our horses looked the best the past two years that

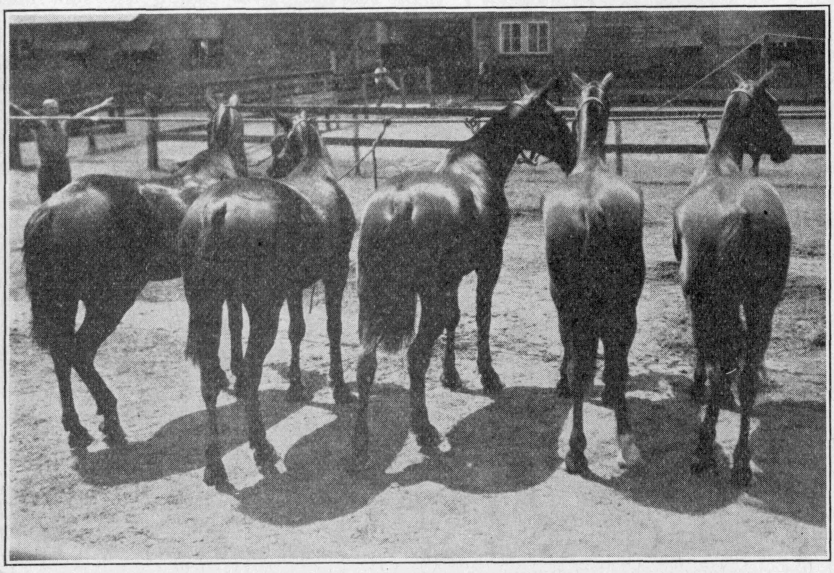

Fig. 9. Some of the light Artillery horses, Group 4, check group, fed the standard army ration during second year's experiment. The horses in this group lost an average of 59 pounds per head during the 224-day feeding period, as compared with a loss of 14 pounds per head in Group 3 (Fig. 8).

they have since I came here in 1926. I consider that we have had nothing but desirable results from feeding one pound of cottonseed meal to artillery horses. There is no doubt about the cottonseed meal being palatable to all except one or two horses. Some of the horses like the meal better than oats and wait until the meal is fed before beginning to eat their grain."

Sergeant P. F. Bowen, who was in charge of the stables, makes the following comments:

"The year before the meal was fed, 15 of the horses were rough, bony, and thin, although we gave them extra feed. These same animals have

picked up on the cottonseed meal and almost all of them have taken on flesh and look better. The horses getting cottonseed meal shed earlier and look more glossy in coat in the early spring than the others. The two horses not eating the cottonseed meal well were 'fussy' feeders and one of them leaves his oats. Not one horse getting cottonseed meal had to go to the hospital during the entire two years and there were some cases of colic in the other group. Not one objection can be made to feeding the cottonseed meal and I would recommend one pound of it daily to old, thin, long-bodied horses which are hard to keep in good condition."

DISCUSSION OF RESULTS (all tests)

Palatability

The cottonseed meal used in these tests seemed to be palatable to horses and mules, since fully 95 per cent of the animals seemed to relish the cottonseed meal included in their rations. It was eaten as readily in the summer as in the winter. The artillery horses were especially fond of it, probably on account of the lack of variety in the regular army ration. About one-half of the artillery horses fed cottonseed meal refused to eat their oats until the meal was fed. Some of the animals required a few days to develop an appetite for the cottonseed meal; others ate it readily the first time it was fed. The weanling colts and a few of the others were slow to learn to relish the meal.

Four fillies were fed two pounds of cottonseed meal per head daily from the time they were weaned up to 686 days. Each of these fillies had excellent appetites and made rapid gains. One work mule, three Percheron mares and a Standard-bred mare each ate two pounds of meal daily for 533 to 602 days without showing any apparent lag in appetite as compared to similar animals not eating cottonseed meal.

General Thriftiness

In every one of nine comparable groups involving more than 80 animals, the ones that received cottonseed meal in their rations gained more than the groups getting no cottonseed meal but receiving the same amount of concentrates.

Among the 12 weanlings used in the experiments, those receiving cottonseed meal gained faster and showed earlier maturity than the ones not receiving cottonseed meal.

The cottonseed meal seemed to cause the animals to shed the old hair early in the spring. This was especially noticeable in the animals fed two pounds of cottonseed meal daily, and it was also apparent in the groups receiving one pound of this supplement daily.

The most probable reason that cottonseed meal effected a general increase in gain and improved the appearance between the comparable groups is that the control rations were low in protein. Cottonseed meal is slightly lower in net energy than corn, milo, or kafir, about equal to oats, but

higher than rice bran, and in addition is much higher in protein than any of these feeds. Cottonseed meal will then replace more than an equal amount of these other feeds so long as there is a need for protein in the ration, and this was apparently true in these feeding tests.

Some horsemen believe that cottonseed meal is "heating" for work animals, and especially during summer. In these experiments the animals receiving cottonseed meal were apparently no more affected by heat than the others. In fact, several of the teamsters thought that the cottonseed meal made the animals more willing workers.

Health

Over 80 horses and mules varying in age from weanlings to 20 years old had one pound of cottonseed meal per head daily included in their ration over a period of 224 days, and some of them were given two pounds

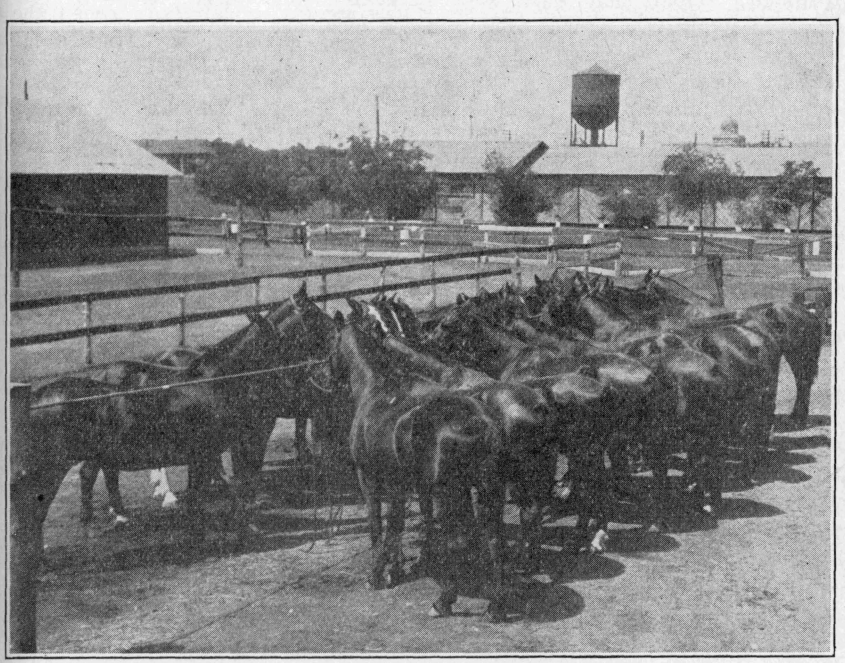

Figure 10. View of the heavy Artillery horses, Group 2, at the end of the second year's experiment. During the first year's test they gained in weight while on a ration in which one pound of cottonseed meal replaced one pound of oats, and during the second year's investigation they lost in weight on the standard army ration.

daily over a much longer period. At the end of the investigation the animals were examined by Dr. R. P. Marsteller, professor of veterinary medicine and surgery, and they were found to be normal in every respect. Not one case can be cited in these studies where cottonseed meal caused injurious results.

The first year three heavy artillery horses fed the army ration had colic one time or another, while none were reported in the group getting cottonseed meal. The second year these horses did not have colic while on the ration that included cottonseed meal. Similarly, there were less frequent occurrences of colic noted among the animals at the Feeding and Breeding Station and at College Animal Husbandry Department when the ration included cottonseed meal.

An increase in urine discharge by the fillies fed two pounds of cottonseed meal per head daily was noted by one of the feeders. However, records of the frequency of urination did not disclose any particular difference between the animals in the different groups.

The character of the feces of the various groups was quite similar and apparently normal.

During the experiments, 24 mares belonging to the College Animal Husbandry Department were bred, 17 foals being raised. None of the mares receiving two pounds of cottonseed meal per head daily aborted or lost foals, but one mare failed to settle one year. This was the best record made by any of the groups of mares. In the group receiving one pound of cottonseed meal per head daily, one old mare failed to settle two years and the other year her foal died of *navel ill.* Of the group not receiving cottonseed meal, two mares aborted and one foal died. It was not possible to measure milk flow between the groups, however, all groups raised large vigorous foals.

Use of Cottonseed Meal in the Ration

Cottonseed meal is too concentrated and too high in protein to be fed in large amounts or as the sole concentrate to horses and mules at work. It should be used in small amounts as a supplement to other feeds, in which case no ill effects can result from its use.

Cottonseed meal is usually higher in price than corn or other grains of high energy content. Fed pound for pound with such feeds in a ration it will not cheapen the ration unless it will replace more than an equal amount of such feeds or unless there is a special need for the protein it supplies. Thus Professor L. V. Starkey (9) reports that one pound of cottonseed meal seemed equal to two pounds of shelled yellow corn when fed to mules on grass to maintain the weight of the animals.

Feeding one to two pounds of cottonseed meal would probably be profitable under the following conditions:

With dry grass or any non-leguminous roughage that has been weathered, along with grain. Both protein and phosphorus become lower in forages with maturity and weathered roughage has little feed value.

When cottonseed meal costs no more than corn or oats.

When the condition of the animals makes special demands upon the body. During the gestation period mares require liberal quantities of protein and minerals, the same being true for young growing stock and mares nursing foals.

When the cottonseed meal will balance the ration with the other available feeds, according to the calculated requirements of the animals. For example 10 pounds of corn, 1 pound of cottonseed meal, and 13 pounds of Johnson grass hay will more nearly fill the requirements of a thousand-pound horse at work than 12 pounds of corn and 12 pounds of hay.

The information is not complete in regard to the amount of protein required by the various classes of horses and mules but many believe that mature work geldings or open mares and mules have low demands for protein. Probably the ordinary farm feeds with occasional pasturage will furnish enough protein for such animals. It would be very doubtful if cottonseed meal need be fed to mature work stock kept on green pasturage and fed grain. The demand for cottonseed meal would also be very low when legume or mixed hay is fed to mature work stock.

No attempt was made in these tests to ascertain the amount of cottonseed meal that various classes would eat, nor was it possible to study the problem of the optimum amount of cottonseed meal that should be fed. There is no proof that either one or two pounds per head daily was the correct amount. However, it is likely that two pounds is more than is required to supplement the ordinary ration. The aim in feeding as much as two pounds was to determine if such an amount could be fed with safety. Both one and two pounds gave good results, and made fairly well balanced rations with the other feeds used. Whether the feeder should use one or two pounds will depend upon the price of cottonseed meal in relation to other feeds and the need of the animals for the protein it supplies.

SUMMARY

1. The average gains per head were larger in each of nine comparable groups, including more than 80 animals of varying ages receiving cottonseed meal, than in the control groups not fed this supplement.

2. The heavy artillery horses that received cottonseed meal made a larger gain each year than the control group fed the standard army ration of oats and prairie hay. The first year, Group 2 receiving cottonseed meal, made an average gain of 23.3±9.5 pounds more than Group 1, the check lot. The second year, Group 1 receiving cottonseed meal, gained 20.9±5.5 pounds more per head than Group 2, the check lot. This is a significant difference in favor of feeding cottonseed meal the second year, but less certain during the first year's test.

3. Young mules and colts fed cottonseed meal from weaning time seemed to develop faster, shed earlier, and weighed more at one year of age than those that did not receive this supplement.

4. Mares receiving two pounds of cottonseed meal were good sucklers and raised vigorous heavy foals.

5. One pound of cottonseed meal in the ration was palatable to 95 per cent of the animals, and there was no difficulty in getting work horses and mules, brood mares, weanling mules, fillies, and young horses to eat two pounds per head daily. Around 5 per cent of the most particular

feeders were slow in acquiring an appetite for the cottonseed meal but none refused to eat it.

6. There were no injurious effects when one or two pounds of cottonseed meal per head daily was added to the rations of the various classes of horses and mules used in this investigation.

7. If correctly fed to horses and mules not otherwise receiving adequate amounts of protein, cottonseed meal will be a useful and economical feed.

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